FLUCTUATION IN TRAP-NET CATCHES IN THE UPPER MISSISSIPPI RIVER

SPECIAL SCIENTIFIC REPORT: FISHERIES No. 101

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

Explanatory Note

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Representatives from the States of Illinois, Iowa, Minnesota, Missouri and Wisconsin and from the United States Fish and Wildlife Service, meeting in December, 1943, formed the Upper Mississippi River Conservation Committee for the purpose of carrying on scientific investigations of the fishery and wildlife resources of the Mississippi River from Caruthersville, Missouri, to Hastings, Minnesota. Field operations were started in 1944.

Washington, D.C.
May, 1953

United States Department of the Interior, Douglas McKay, Secretary
Fish and Wildlife Service, Albert M. Day, Director

FLUCTUATION IN TRAP NET CATCHES IN THE UPPER MISSISSIPPI RIVER

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ILLUSTRATIONS

The upper Mississippi River supports an important sport and commercial fishery. To obtain better management of this fishery as well as the other wildlife resources of the river, the Upper Mississippi River Conservation Committee was organized in 1943. Represented on the committee were the official conservation agencies of the states of Missouri, Illinois, Iowa, Wisconsin and Minnesota, and the United States Fish and Wildlife Service.

Under guidance of the committee a project was set up for gathering information about the fish population of the Mississippi River by a series of test-netting surveys. These were carried out during the years 1944-48 and consisted (1) of netting by traveling crews at stations between Caruthersville, Missouri and Hastings, Minnesota and (2) of netting throughout the open-water season at permanent stations near La Crosse, Wisconsin. The latter work was done in 1948 and it is with the fluctuations of trap net catches at these permanent netting stations that the present paper is concerned.

Quantitative interpretation of net catches presents many difficulties. As had been pointed out by Hartly (1947) and Moyle (1950), the catch of passive fishing gear such as hoop, fyke, gill and trap nets depends not only on the abundance of fish large enough to be taken and held by the nets but is also influenced by the rate of activity of the fish. These factors as well as others related to them must be considered if net catches are to be used as a quantitative measure of the size and structure of fish populations. This paper attempts to evaluate some of the factors found to influence the catch of trap nets in the Mississippi River during the summer of 1948.

AREA FISHED

The catches considered here were all made in the upper third of Pool 8, formed by the dam at Genoa, Wisconsin. This part of the Mississippi consists of a large number of backwater lakes and interconnecting channels all directly or indirectly connected with the main navigation channel. The area fished is shown in Figure 1.

Most of the backwater lakes have no current in them except during high water periods in the early spring. There is usually a slight current in the connecting channels and there is always current in the main navigation channel. Where current is rapid the bottom is usually of shifting sand. Where there is little or no current the bottom is usually of mud or silt.

At most places aquatic vegetation is not abundant, being limited by shifting bottoms, turbidity, current, and fluctuating water levels. Submersed aquatic plants, mainly coontail (Ceratophyllum demersum), were

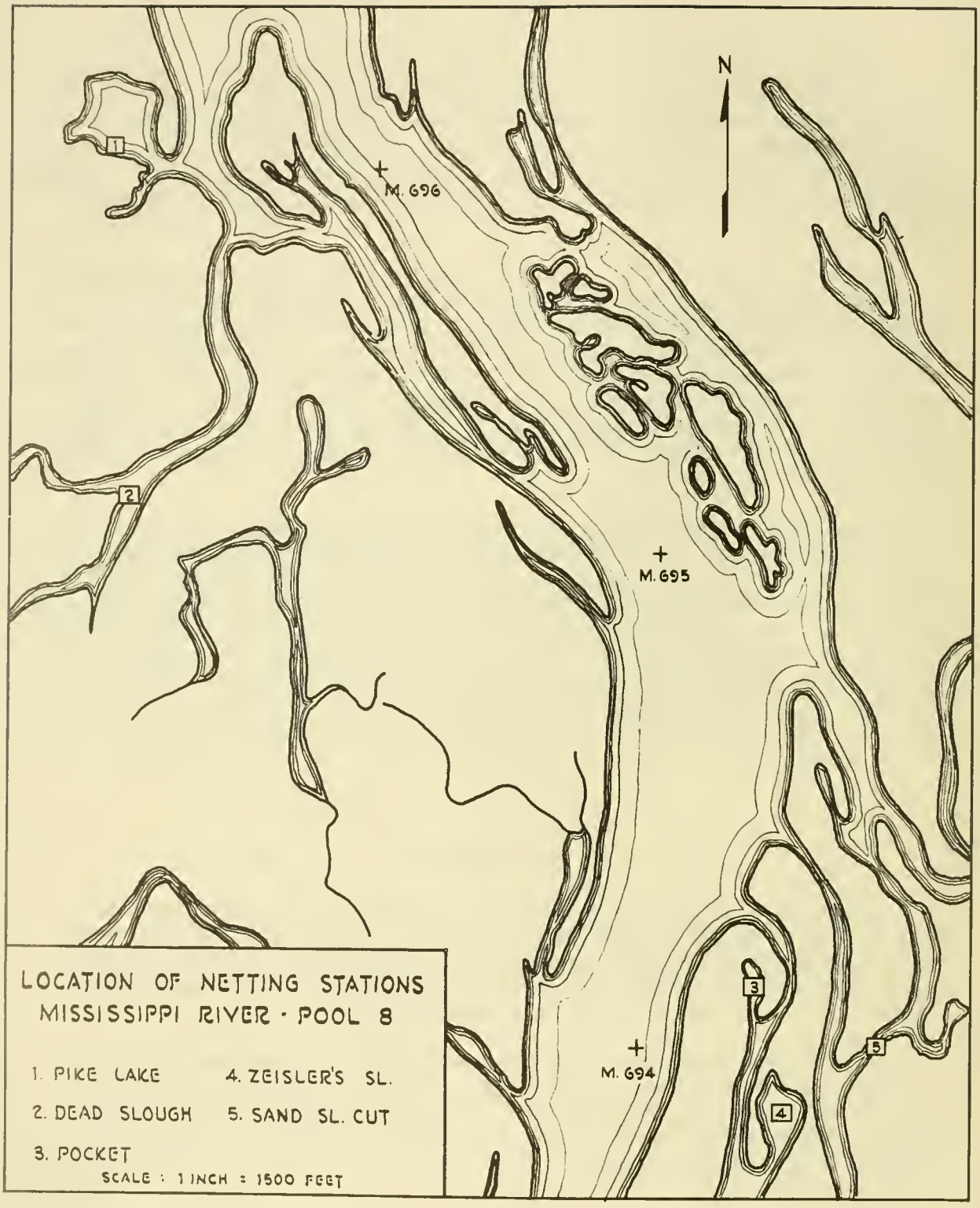

Fig. 1--Pool 8 of the Mississippi River immediately below La Crosse, Wisconsin showing the locations of trap-netting stations during the summer of 1948. Crosses locate numbered channel markers. Broken Arrow Slough in which some buffalo nets were set is 1,500 feet south of Marker 696.

common only in the more isolated backwaters. Emergent aquatic plants were more generally distributed, the common kinds being lotus (Nelumbo pentapetala) and arrowhead (Sagittaria latifolia).

Pool 8 supports a commercial fishery which took 850,000 pounds of fish during the 1948 season.1/ The important commercial fishes are carp, sheepshead, buffalo and catfish. Parts of this pool are popular fishing grounds for anglers from southwestern Wisconsin and southeastern Minnesota. Good catches of walleyes, northern pike, panfishes and catfish are frequent. In the area netted, however, angling pressue is so light that the effect of angling take on the fish population and on net catches may be considered negligible.

GEAR USED

The trap net was used to sample fish populations at the permanent netting stations in 1948 and for other netting surveys conducted north of Dubuque, Iowa. This net is illustrated in Figure 2. It takes most of the species of fish present in the river and appears to be less selective than most other kinds of entrapment gear. It is easily handled by two men and in an emergency can be raised and reset by one man. Since the trap net offers considerable resistance to current it does not operate well in fast waters.

The fore-part of the net is a box-like frame, six feet wide, three feet high, and two and a half feet deep, to which a 50-foot lead is attached. The rear of this frame is fastened to a hoopnet of seven hoops. In the frame is a heart which serves as the first throat of the net and in the hoop-net portion are two throats, the first square and the second tapered or "fingered". Mesh of the webbing on the frame is 1-1/4 inch bar measure and on the hoops is 1-inch bar measure. The trap nets used in this study were set at right angles to the bank with the lead extended from the center of the frame to the shore.

To gain some additional information in fast-water areas, large-mesh commercial buffalo nets were also fished. The buffalo net is a large hoopnet, about 13 feet long, with 7 to 10 hoops that are 3 to 4 feet in diameter. Mesh of the webbing varied from 1-3/4-inch to 2-inch bar measure. Buffalo nets were fished without leads or wings and were anchored in the current to intercept fish moving up stream. Buffalo nets are used by commercial fishermen to take buffalo, sheepshead and carp from the Mississippi below Dubuque, Iowa, but are illegal in Wisconsin-Minnesota boundary waters.

1/ Sixth Progress Report, Upper Mississippi River Conservation Committee. Technical Committee for Fisheries, 1950

Fig. 2--Mississippi River trap net used for test netting.

METHODS

In 1948, permanent netting stations were selected in Pool 8 at five locations shown in Figure 1. Beginning on May 15, one trap net was set at each of the stations. Each net was lifted daily between 8 and 11 A.M., the catch removed and the net immediately reset. Fishing in this manner was continued for 10 days after which the nets were removed for a "rest period" of 4 to 6 days. During the rest period the nets were repaired and treated with copper napthenate preservative.

Such 10-day netting periods alternating with 4 to 6 day idle periods continued through September 25, making a total of nine netting periods. In following portions of this paper these netting periods will be designated by the Roman numerals I through IX. They are dated as follows:

Period I	- May 15	through May 24
II	- May 31	through June 9
III	- June 17	through June 26
IV	- July 1	through July 10
V	- July 18	through July 27
VI	- August 3	through August 12
VII	- August 18	through August 27
VIII	- September 1	through September 10
IX	- September 16	through September 25

During the nine netting periods 325 successful trap-net lifts were made. The results of 125 other lifts were discarded because of muskrat, beaver or human interference with the nets. One of the five netting stations was abandoned during Period IX because of muskrat activity.

All fish taken in the trap nets were counted, weighed and measured. After the middle of June scales were taken from a selected sample of each species of fish. Gross examination was made of the state of gonad development of many of the fish.

During the netting a careful record was kept of water temperature and water turbidity at the time each net was raised. Turbidity readings were made with a platinum needle turbidimeter. Water level and rainfall records were obtained from the U. S. Weather Bureau at La Crosse.

Data for each net lift were recorded separately in code suitable for tabulation on an IBM punch card machine.

STATISTICAL CONSIDERATIONS

The use of trap-net catches for evaluation of size and structure of a fish population is essentially a sampling problem. Means calculated from trap net catch data are subject to sampling error and some method

for judging the validity of such means must be used if the mean catches from the 10-day netting periods are to be compared. An attempt was made to judge sampling errors by standard statistical procedures, but the data appeared not amenable to this type of treatment. The distribution of the catches is skewed and random sampling of the individual fish in the population cannot be assumed. As pointed out by Moyle (1950) for the catch of gill nets, the skewness of the catch pattern and the apparent non-random nature of the sampling probably reflects the associative patterns of the fishes themselves.

Instead of standard error a more general and empirical method has been used for judging the validity of catch means. Mean catch for each species, in terms of weight and numbers of fish per lift, was calculated for each of the 4 or 5 nets used during each netting period. If the mean catch in at least 75 percent of the nets - that is, 3 out of 4 or 4 out of 5 - was higher or lower than in the preceding period, the trend was regarded as real and probably not due to sampling errors. Changes of a lesser degree are considered to be uncertain. All fluctuations discussed in this paper meet this requirement, unless otherwise specified.

This method of judging reliability of means is similar to that of Hubbs and Perlmutter (1942) who in attempting to apply statistical procedures to fish systematics concluded that "Even when no single sample of one group can be demonstrated as significantly different from that of another group, a true distinction between the two categories must nevertheless be accepted, if the difference is shown consistently by enough small samples of each group."

SEASON TRENDS IN CATCH OF TRAP NETS

During this study 12,810 fish weighing 11,254 pounds were taken in trap nets. Thirty-five species of fish were caught but only 11 species were taken in quantities adequate to demonstrate catch trends. Arranged in the order in which they will be discussed they are:

Black crappie - Pomoxis nigro-maculatus
White crappie - Pomoxis annularis
Bluegill - Lepomis macrochirus
Northern pike - Esox lucius
White bass - Lepibema chrysops
Channel catfish - Ictalurus lacustris punctatus
Flathead catfish - Pilodictus olivaris
Northern redhorse - Moxostoma aureolum
Carp - Cyprinus carpio
Carpsucker - Carpiodes spp.
Sheepshead - Aplodinotus grunniens

Black crappies, white crappies and bluegills were taken in much greater numbers than the other species and allow more thorough analysis of catch fluctuation than is possible for the other species. A summary of the findings for each of these three species will conclude the discussion of each. A general summary and discussion of catch fluctuations for all species will be found at the end of the paper.

BLACK CRAPPIE CATCH TRENDS

During the nine netting periods 4,104 black crappies weighing 1,854 pounds were taken in the trapnets. Fluctuations and trends in the catch of the black crappie are shown in Table 1 in terms of mean number and mean weight per net lift for each netting period. The mean catch per net lift for each period is also expressed as a percentage of the mean catch per net lift for the entire netting season - all nine periods. This latter method of presentation places all catches whether expressed as numbers or pounds on a comparative scale.

Table 1 shows that the catch of black crappies declined during the first part of June; remained at a low catch level for a few weeks, and then began to rise. This rise was interrupted during the first part of August (Period VI) by a slight drop in the catch at all but one station. After August 18 the catch increased in a more or less rapid and regular fashion and reached a high point for the season in the last fishing period (September 16 to 25).

The effect of four main factors on the catch of black crappies will be considered. They are (1) recruitment to the catch; (2) losses from the fish population; (3) activity and movement of the fish; and (4) spawning activities.

1. Recruitment to the Black Crappie Catch.

Recruitment to the catch of the black crappie was studied by (1) analysis of the changes in length-frequency of the catch during the netting, and (2) age and growth determinations from scales collected during the netting.

Length-frequency distributions of the catch during each of the nine netting periods are shown in Figure 3. It will be noted that all black crappies caught during Period I (May 15 to 24) were 7 inches long or longer. Age determinations from scales collected indicate that these fish were of the 1945, 1944 and 1943 year classes. These 3, 4 and 5-year old fish may be termed the "residual" fish for they were both (1) large enough to be taken in the nets during Period I, and (2) present in the area being netted during Period I.

Table 1. Seasonal fluctuation in mean trap net catches of black crappies.

Period	Dates inclusive	Numbers		Pounds	
		Per lift	Percent of season's mean catch per lift	Per lift	Percent of season's mean catch per lift
I	May 15 - 24	16.8	121.8	11.7	186.0
II	May 31 - June 9	2.7	19.6	1.4	22.0
III	June 17 - 26	2.5*	18.1*	1.2*	19.2*
IV	July 1 - 10	5.3	38.4	2.3	36.5
V	July 18 - 27	8.2	59.5	2.8	44.5
VI	August 3 - 12	6.6	47.9	2.3	36.7
VII	August 18 - 27	12.9	93.5	6.8	108.0
VIII	September 1 - 10	16.0*	116.0*	6.4*	101.7*
IX	September 16 - 25	53.6	388.4	21.5	341.9
Mean catch for season		13.8	100.0	6.3	100.0

Starred (*) figures represent catches considered take not significantly different from catch of the preceding period. See text for explanation.

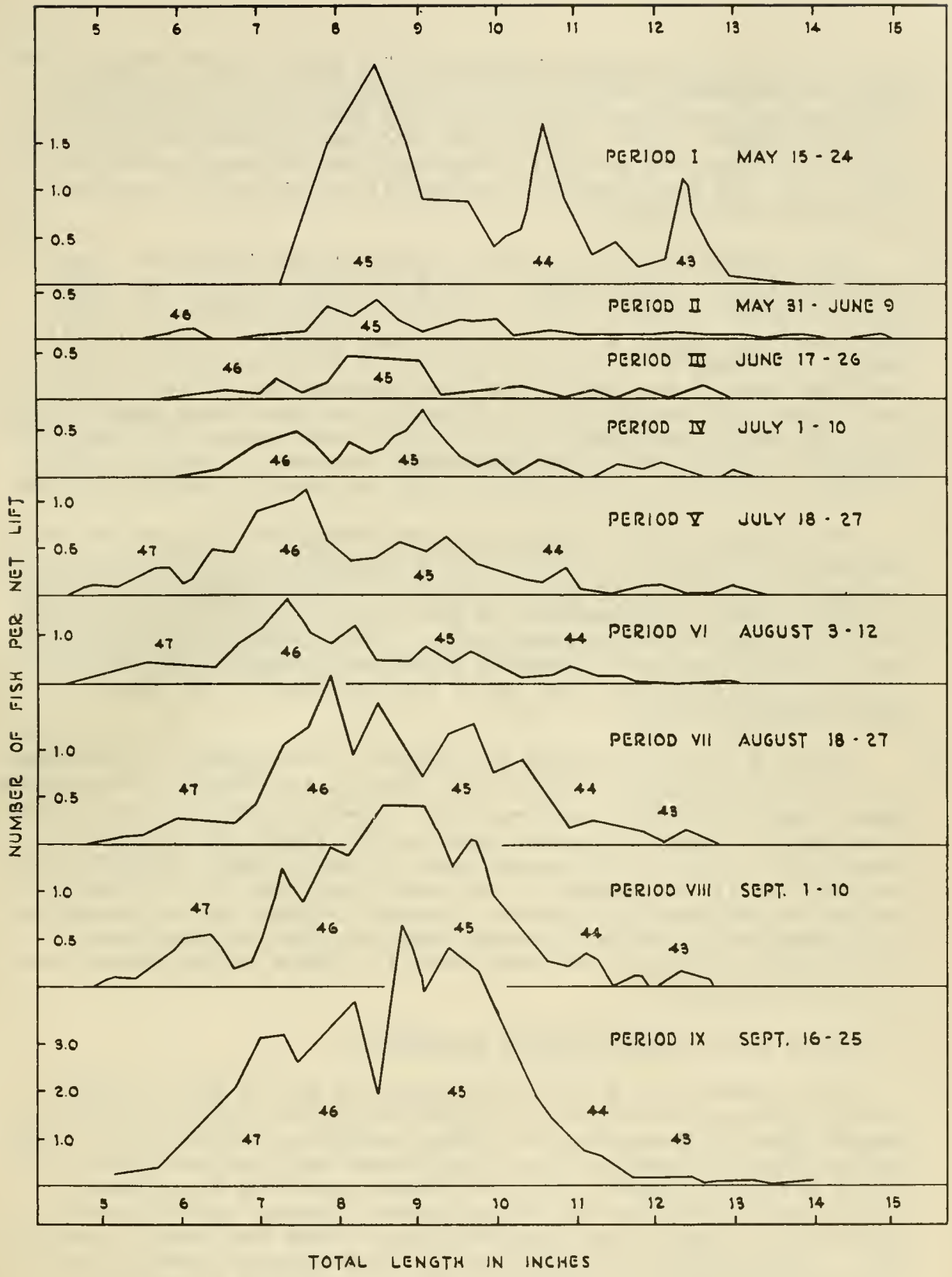

Fig. 3--Length-frequency distribution of black crappies for the nine netting periods. Approximate distribution of year-classes was determined from scales.

It will also be noted from Figure 3 that smaller black crappies were caught in increasing numbers during later periods. Age determinations from scales of these fish demonstrated that they were of the 1946 and 1947 year classes. These 1- and 2-year old black crappies may be termed "recruitment" for they were (1) the younger fish not large enough to be held in the nets during Period I, and/or (2) not present in the area being netted during Period I.

Table 2 lists the mean catches of "residual" and "recruited" black crappies for each netting period. The first recruitment to the catch began in Period II (May 31-June 9) when a few individuals of the 1946 year class were taken. A month later (Period IV) these 2-year old fish made up 33 percent of the catch in numbers of fish. A few of the 1947 year class entered the catch during the following netting period (V) when "recruited" fish made up 59 percent of the total black crappie catch. During August and September, the 1947 year classes entered the catch in increasing numbers. The total "recruited" fish made up from 39 to 65 percent of the mean black crappie catch of the last four netting periods.

The appearance of the 1946 year class during June and July did not coincide with the growth of these fish to catchable size. The nets readily retained black crappies as small as 5 inches and growth analysis of the 1946 year class demonstrated that most of these fish were larger than that when the netting began in May. Their absence at that time and their sudden appearance in quantity during July suggests that they were not associated with older fish during the early part of the season but joined them during July.

Figure 4 shows graphically the effects of recruitment upon the catch. The rise in catch during July probably reflects the effects of recruitment alone; that is more fish large enough to be held by the nets were available to be caught. The still greater catch rate in August and September is probably the result of (1) augumentation of the population by previous recruitment and (2) an increase in the rate of activity of all crappies in the population during late summer. Catch of the nets can be regarded as an arithmetical product of abundance times activity and large catch fluctuations may be expected when there is a change in the activity rate of large populations.

2. Losses from the Black Crappie Population.

It is likely that some of the increase in size of the catchable black crappie population during the four and a half months was offset by various types of losses such as natural mortality, fishing mortality and perhaps migration from the area. Such losses would influence the catch at the end of the season. From the present data there is no means of estimating the total loss to the population. However there is some evidence of a greater loss among older age classes than among 3-year-old fish. During Period I, 4 and 5-year old black crappies made up about 35 percent of the catch in numbers of fish; the remaining 65 percent con-

Table 2. Mean catch of "recruited" and "residual" black crappies expressed as numbers per net lift and percentage of the total catch for each netting period.

Period	I	II	III	IV	V	VI	VII	VIII	IX
	May 15-24	May 31 June 9	June 17-26	July 1-10	July 18-27	Aug. 3-12	Aug. 18-27	Sept. 1-10	Sept. 16-25
Recruited									
Number per lift	-	0.2	0.4	1.8	4.8	4.3	5.4	6.2	22.5
Percent of total	-	7	16	33	59	65	42	39	42
Residual									
Number per lift	16.8	2.5	2.1	3.5	3.4	2.3	7.5	9.8	31.1
Percent of total	100	93	84	67	41	35	58	61	58
Total number per lift	16.8	2.7	2.5	5.3	8.2	6.6	12.9	16.0	53.6

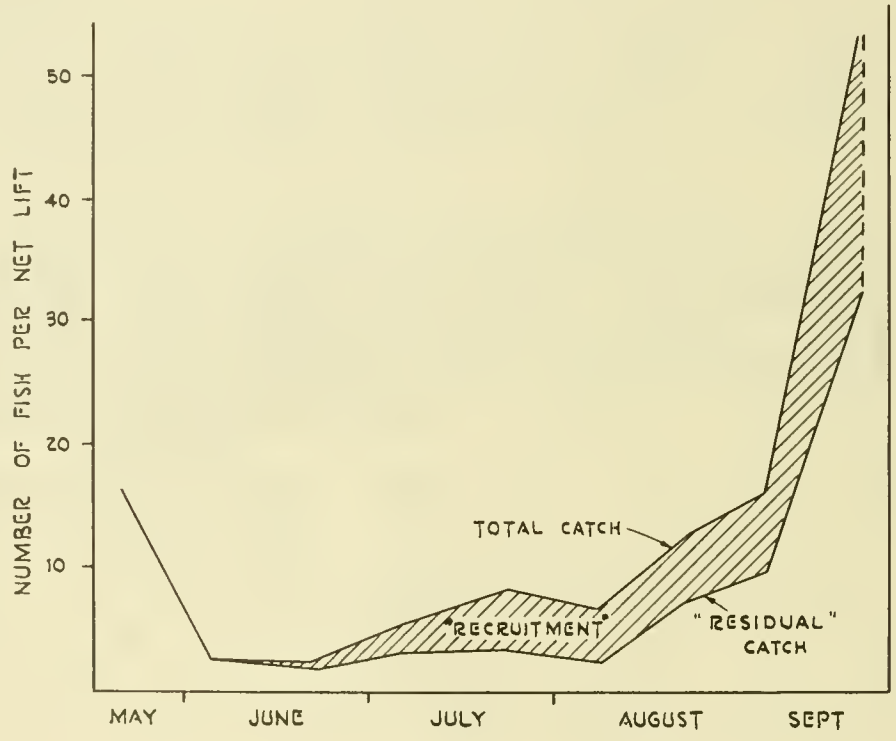

Fig. 4-- Fluctiations in black crappie catch showing effect of "recruitment". Data from Table 2.

sisting of 3-year old fish. During Period IX only about 11 percent of the catch of these three age groups consisted of 4 and 5-year old fish.

As a check on the effects of removing fish from the area by netting, a trap net was set in Broken Arrow Slough during Period IX. This area had not been netted before. This net took black crappies of approximately the same length-distribution during Period IX as did the other nets which had been fished all summer at the permanent netting stations. This observation indicates that removal of the fish from the waters around the netting stations probably did not significantly affect changes in length-frequency of the catch.

It is also possible that migration influenced the catches during the season. However, buffalo nets set in the main channel caught only an occasional crappie during the study. Their mesh was small enough to take black crappies over 9.0 inches long. It appears that any losses from the population due to migration are small and that the principal cause of losses was natural mortality.

3. Activity of the Black Crappie.

Two catch fluctuations noted during the season can best be attributed to changes in rate of activity of the fish. They are (1) the marked drop in catch rate that occurred between Periods I and II when only the "residual" population was present and (2) the great increase in catch rate observed in late August and September after most of the recruitment to the population had occurred. A small drop in catch rate was also noted between Periods V and VI, that may also be related to a change in rate of movement.

Some changes in activity rate are probably related to changes in environmental conditions. It will be noted from Figure 5 which shows water levels and water temperatures, that the decrease in catch in June was coincidental with the stablization of water levels. There was a drop in water levels of 1.6 feet during Period I and by the beginning of Period II, the water levels had dropped another 0.6 foot. After the beginning of Period II, the water level remained within 0.2 feet of normal pool stage for the rest of the season. It is generally believed by commercial fishermen who fish the area that water level fluctuations affect fish movement.

Water temperature is also known to affect fish movement and behavior patterns (Fry and Hart, 1943). Means of temperatures taken one foot below the surface of the water each day at each netting station are shown in Figure 4. Catch of black crappies was highest when the water temperature was between 60° and 70° F.; that is during the spring and fall. Fluctuations of water temperatures above 70° F., seemed to have no consistent effect on the catch.

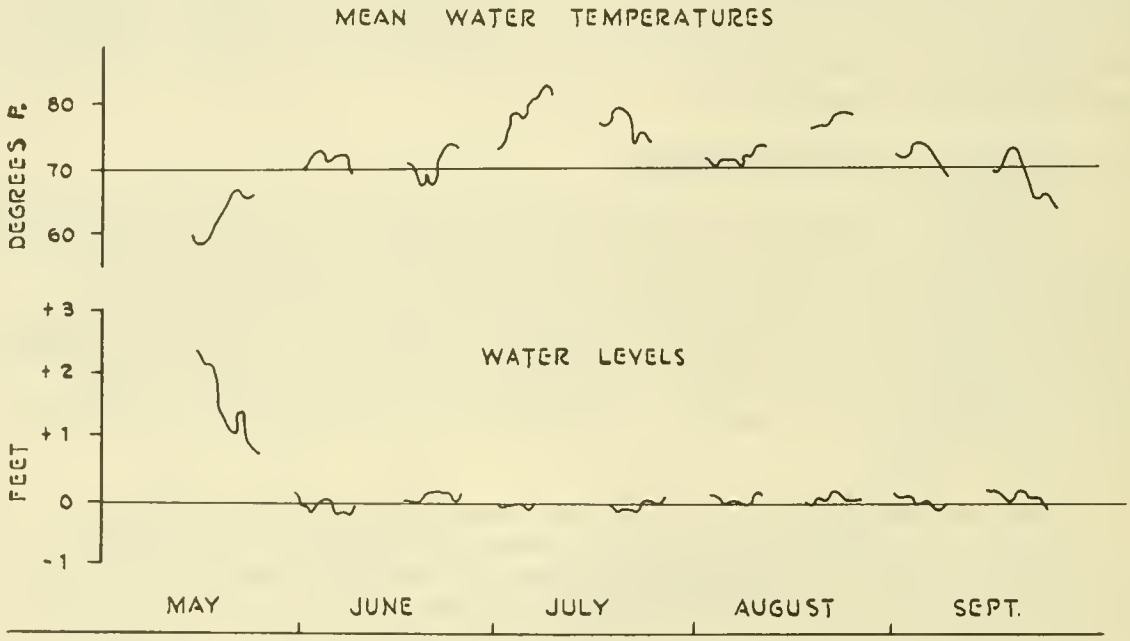

Fig. 5--Fluctuation in water levels and mean water temperature in Pool 8 of the Mississippi River during the summer of 1948. "0" water level in normal pool stage.

Turbidity readings were also made daily at each station. These readings ranged from 22 to 114 parts per million. There is no evidence that turbidity within this range had any effect upon the movement and catch of black crappies or any other species.

4. Effect of Spawning Activities on the Catch.

Direct observation of spawning activities was not possible because of the turbidity of the water, but gonads of 3,311 black crappies were examined grossly and classified as to stage of development. The classification consisted of six categories: (1) undeveloped, (2) developing, (3) ripe, (4) ripe and discharging when pressed, (5) partly spent and (6) spent. A summary of the data on gonad examination is shown in Table 3.

It will be noted that spawning was in progress at the beginning of netting and continued until late in July. During the last half of August all the crappies examined had undeveloped gonads. Development of the gonads for spawning the next year began in some fish in August and was observed in more and more fish as the season progressed. The appearance of the 1946 year class and general mixing of the crappie population was coincidental with the end of the spawning season. Although most of the 2-year-old fish were apparently not with the older fish during the spawning season, gonad examinations show that at least some of these younger fish were capable of spawning and may have spawned elsewhere. Gonad examinations of 10 black crappies all under 7.6 inches long, which were taken during Period III, showed six undeveloped, three partly spent and one ripe.

The present findings on age at sexual maturity of the black crappie agree with the statement of Smith and Moe (1944) that black crappies are sexually mature at the age of two years.

Except for the apparent separation of the older and younger crappies during the spawning and the subsequent remixing of the population, spawning activities had no apparent effect on the catch.

SUMMARY OF BLACK CRAPPIE CATCH TRENDS

1. The means of black crappie trap net catches for each of the nine netting periods fluctuated between 2.5 and 53.6 fish per net lift and between 1.2 and 21.5 pounds of fish per lift. There was: (1) a sharp drop in catch during the first part of June; (2) a gradual rise during which catch was more than tripled during July; (3) a slight but general drop during the first part of August; (4) a rise during which catch was about doubled during the last half of August; and (5) an increase in the latter half of September during which catch again was more than tripled.

Table 3. Gonad development of black crappies, showing percentage of gonads examined that were assigned to each developmental stage.

Period	I May 15-24	II May 31 June 9	III June 17-26	IV July 1-10	V July 18-27	VI Aug. 3-12	VII Aug. 18-27	VIII Sept. 1-10	IX Sept. 16-25
Number examined	484	117	75	176	315	271	611	553	709
Undeveloped	0.2	9.4	48.0	63.1	94.6	99.3	89.2	73.2	61.9
Developing	-	-	-	-	-	-	10.8	26.8	38.1
Ripe	46.7	29.9	8.0	0.6	-	-	-	-	-
Ripe *	45.2	6.8	1.3	1.7	1.3	-	-	-	-
Partly spent	6.8	53.0	42.7	34.6	2.5	-	-	-	-
Spent	1.0	0.8	-	-	1.6	0.7	-	-	-

2. Recruitment to the catch consisted of the sudden appearance of the 1946 year-class during July after the spawning season and the gradual appearance of the 1947 year-class during and after the last part of July. The recruitment affected catch fluctuations in two ways. First it caused the increase in catch as the recruitment occurred, and second, it increased the magnitude of subsequent catches and catch fluctuations resulting from changes in the rate of activity.

3. The drop in catch during the first part of June is thought to have been caused by a decrease in the rate of activity of the black crappie. This may have been caused either by (1) stabilization of water level during Period II; (2) water temperatures rising above 70 degrees F. during Period II or (3) a combination of these two changes in the environment.

4. The increases in catch during August and September are attributed to the combined effect of previous recruitment and increased rate of activity.

WHITE CRAPPIE CATCH TRENDS

During the nine periods of netting, 929 white crappies, weighing 456 pounds were taken in the trap nets. Seasonal fluctuation of this catch is shown in Table 4 which lists the mean catch per lift for each netting period. Seasonal fluctuation in the catch of white crappies was less than that already noted for black crappies.

The white crappie catch dropped during the first part of June. After this period no significant change occurred in the catch until the latter part of July, when the catch almost doubled. By the last of August the catch had declined to a level somewhat above the June catch rate. During the last half of September, a small rise in catch was observed.

1. Recruitment to the White Crappie Catch.

Length-frequency of the white crappie catch during each netting period is shown in Figure 6. All white crappies taken in trapnets during Period I were 7.0 inches long or longer. Age determinations from white crappie scales collected during the netting indicate that most of these fish were of the 1945, 1944 and 1943 year classes - the "residual" population.

Table 5 shows the relative numbers of "recruited" (1946 or younger year classes) and "residual" (1945 or older year classes) white crappies taken during each netting period. These data have been used in Figure 7 to show the effect of recruitment upon catch.

Recruitment to the white crappie catch did not begin until Period IV (July 1-10) when the 1946 year class made up 19 percent of the total catch in numbers of fish. During Period V, (July 18-27) the 1946 year class,

Table 4. Seasonal fluctuations in mean trap net catches of white crappies.

Period	Dates inclusive	Numbers		Pounds	
		Per lift	Percent of season's mean catch per lift	Per lift	Percent of season's mean catch per lift
I	May 15 - 24	4.0	138.0	2.9	207.2
II	May 31 - June 9	1.9*	65.5	1.3*	93.0
III	June 17 - 26	2.0*	69.0	1.3*	93.0
IV	July 1 - 10	2.1*	72.4	1.1*	78.5
V	July 18 - 27	3.9	134.4	1.6*	114.2
VI	August 3 - 12	3.2*	110.3	1.1*	78.5
VII	August 18 - 27	2.7*	93.1	1.2	85.7
VIII	September 1 - 10	2.6	89.6	1.0	71.4
IX	September 16 - 25	3.4	117.2	1.4	100.0
Mean catch for season		2.9	100.0	1.4	100.0

Starred (*) figures represent catches considered not significantly different than catches of the period immediately preceding.

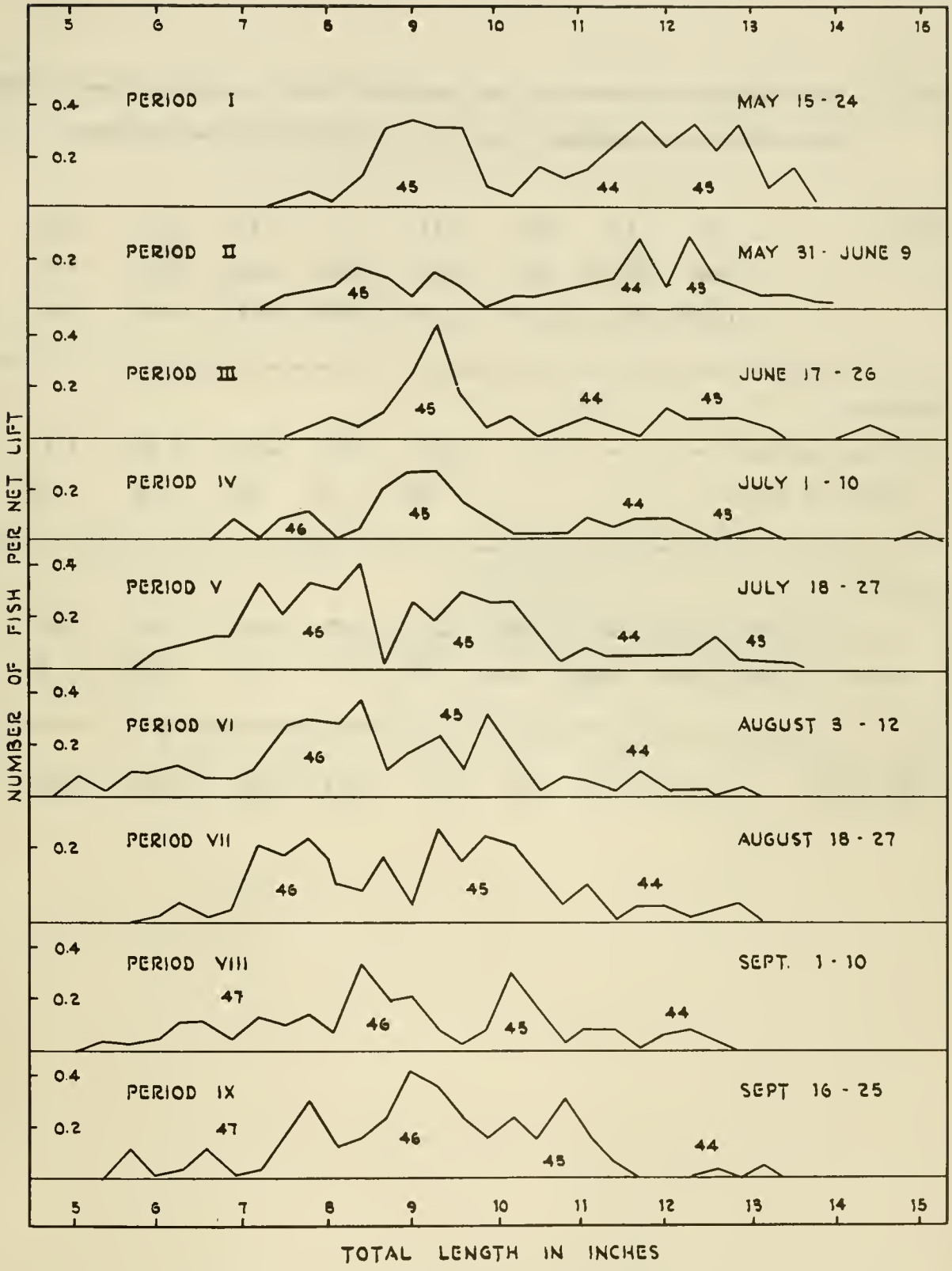

Fig. 6--Length-frequency distribution of white crappies for the nine netting periods. Approximate distribution of year-classes was determined from scales.

Table 5. Mean catches of "recruited" and "residual" white crappies expressed as numbers per net lift and percentage of the total catch for each netting period.

Period	I May 15–24	II May 31 June 9	III June 17–26	IV July 1–10	V July 18–27	VI Aug. 3–12	VII Aug. 18–27	VIII Sept. 1–10	IX Sept. 16–25
Recruited									
Numbers per lift	-	-	-	0.4	2.0	2.0	1.2	1.7	2.3
Percent of total	-	-	-	19	51	61	45	65	67
Residual									
Number per lift	4.0	1.9	2.0	1.7	1.9	1.2	1.5	0.9	1.1
Percent of total	100	100	100	81	49	39	55	35	33
Total number per lift	4.0	1.9	2.0	2.1	3.9	3.2	2.7	2.6	3.4

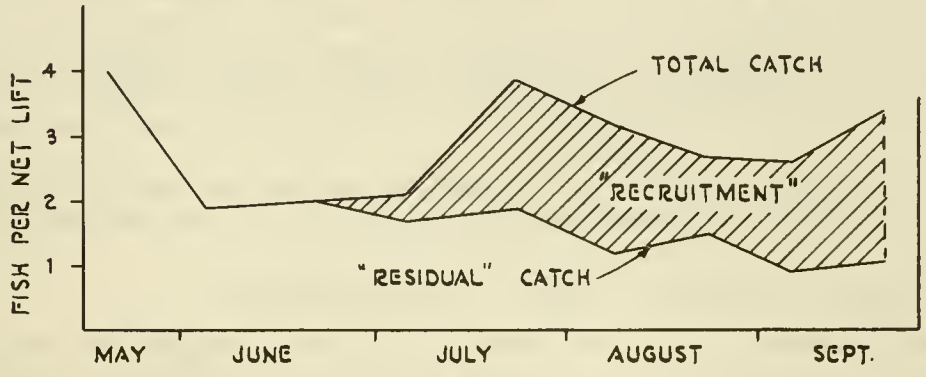

Fig. 7--Fluctuation in white crappie catch showing the effect of "recruitment". Data from Table 5.

plus possibly a few individuals of the 1947 year class made up 51 percent of the total numbers of white crappies caught in trap nets. This sudden recruitment resulted in the increase in catch observed during July. Additional recruitment from the 1946 year class and the 1947 year class kept the white crappie catch from falling below the low catch level of June in August and September.

2. Losses from the White Crappie Population

There is evidence of considerable mortality among older white crappies during the summer (Figure 6). During Period I, 60 percent of the catch of white crappies, that were three years old or older ("residual" population), consisted of 4 and 5-year old fish. By Period IX these older fish made up only seven percent of the catch.

The trap net fished in previously unnetted Broken Arrow Slough during Period IX caught too few white crappies to allow comparison of length-frequency distribution here, with that of the catch from regular netting stations during Period IX. However, it seems doubtful that enough white crappies were removed from regular netting stations during the season to effect noticeably the size structure of the white crappie population.

No migration of older white crappies was noted during the season and the loss of older fish was probably due mostly to natural mortality.

3. Activity of the White Crappie and the Catch.

Two fluctuations in the catch of the white crappie can be related to changes in the activity rate. They are (1) the decreases in catch during the first part of June, and (2) the increase in catch during the last part of September.

Changes in the rate of activity that apparently caused these catch fluctuations are probably related to changes in water levels and temperature. The decline in catch during the first part of June coincided with the stabilization of the water levels after the spring high water period. Dropping water levels may have caused the higher catch during Period I and their stabilization may have resulted in the lower catch rate during Period II. This drop in catch also coincided with the warming of the water to above 70 degrees F.

Examination of gonads of white crappies throughout the season showed that spawning activities were probably at a peak when netting began (Table 6). Spawning activites declined steadily until mid-June when 96 percent of the white crappies examined were found to have undeveloped gonads.

There was no apparent change in catch rate from the "residual" population as spawning activities declined and the increase in catch rate in July can be attributed to the entrance of 2-year-old white crappies into

Table 6. Gonad development of white crappies, showing percentage of gonads examined that were assigned to each developmental stage.

Period	I May 15–24	II May 31 June 9	III June 17–26	IV July 1–10	V July 18–27	VI Aug. 3–12	VII Aug. 18–27	VIII Sept. 1–10	IX Sept. 16–25
Number examined	99	83	62	68	132	130	119	87	65
Undeveloped	-	4.8	12.9	48.5	96.2	99.2	85.9	75.9	61.5
Developing	-	-	-	-	-	-	11.8	24.1	38.5
Ripe	57.6	50.6	24.2	2.9	-	-	-	-	-
Ripe +	38.3	21.7	6.4	-	-	-	-	-	-
Partly spent	3.0	22.9	56.4	48.5	3.8	-	-	-	-
Spent	1.0	-	-	-	-	0.8	2.5	-	-

the catch. Growth analysis suggests that these 2-year-old white crappies were, like the 2-year-old black crappies, large enough to be taken during the earlier netting periods. Because they were not taken, it appears that the 2-year-old white crappies were elsewhere during the spawning of the older fish and joined the older fish only after spawning was completed. Gonads of the 2-year-old white crappies that were examined were found to be undeveloped so it is probable that most of these fish were not capable of spawning during the 1948 season.

SUMMARY OF WHITE CRAPPIE CATCH TRENDS

1. The means of white crappie trap net catches for the nine netting periods fluctuated betwen 1.9 and 4.0 fish per net lift and between 1.0 and 2.9 pounds of fish per net lift. There was (1) a drop during the first of June, (2) a rise during the last of July, (3) a gradual decline until mid-September, and (4) a small rise in the catch during the last half of September.

2. The decline in catch rate during the first of June is thought to have been caused by a decrease in activity rate of the white crappie. This decrease in activity rate may, in turn, have been related to (1) stabilization of water levels after spring high water, (2) water temperatures rising to above 70 degrees F., or (3) both of these factors.

3. The rise in catch during July was caused by the entrance into the catch of the 1946 year class after the spawning activities of older fish ceased. Recruitment of this 1946 year class during July and of the 1947 year class during August, held up the catch rate during August and September.

4. The slight increase in catch rate during the latter half of September is thought to have been caused by the combined effects of an increased rate of activity, and previous recruitment.

BLUEGILL CATCH TRENDS

During the nine netting periods 4,448 bluegills weighing 1,218 pounds were caught in trapnets. Seasonal catch fluctuations can be judged from Table 7 which shows the mean catch per net lift for each of the nine netting periods. Bluegill catch rate dropped significantly during the first part of June, remained at a low level until July, and rose during July, August and September. During the last netting period (September 16-25) the bluegill catch was about 40 times what it had been during Period II (May 31-June 9).

Table 7. Seasonal fluctuations in mean trap net catches of bluegills.

Period	Dates inclusive	Numbers			
		Per lift	Percent of season's mean catch per lift	Per lift	Percent of season's mean catch per lift
I	May 15 - 24	6.9	46.9	2.6	65.0
II	May 31 - June 9	1.3	8.8	0.5	12.5
III	June 17- 26	2.6*	18.4	1.0*	25.0
IV	June 1 - 10	3.2	21.8	1.0*	25.0
V	July 18 - 27	6.2*	42.2	1.2*	30.0
VI	August 3 - 12	7.9	53.7	1.7	42.5
VII	August 18-- 27	17.4	118.3	5.5	137.5
VIII	September 1 - 10	35.4	240.8	9.2	230.0
IX	September 16 - 25	51.1	348.0	13.5	337.2
Mean catch for season		14.7	100.0	4.0	100.0

Starred (*) figures represent catches that are considered not significantly different from catches of preceeding periods. See text for explanation.

1. Recruitment to the Bluegill Catch.

Length-frequency distributions of the bluegill catches during each netting period are shown in Figure 8. All bluegills caught during Period I were 5.2 inches long or longer. Age determinations from scales collected during the netting indicates that these fish were probably all of the 1945 or older year classes; that is of the "residual population".

Table 8 lists the relative numbers of "recruited" fish (1946 and younger year class) and "residual" fish (1945 and older year class) in the catch during each netting period. These data are presented graphically in Figure 9.

Recruitment began during Period II when a few fish of the 1946 year class appeared briefly in the catch. During Period IV, more of these 2-year-old fish were caught, and in Period V they made up 81 percent of the total number of fish caught. Additional recruitment from the 1946 year classes together with the 1947 year classes continued until September. During September 92 percent of the bluegills being caught were "recruited" fish that had not been available at the beginning of netting in May.

Like the 2-year-old black crappies and white crappies, the 2-year-old bluegills were large enough to have been caught during May and June had they been available, then. Their sudden appearance in quantity during July suggests that they were not associated with the older bluegills during the early part of the season. Since these younger fish first appeared at stations closest to the main river channel, it may be that during early spring they were in the deeper waters of the river. The recruitment of the 1947 year class seems to coincide with their growth to catchable size.

2. Losses from the Bluegill Population.

As with the black and the white crappie, there is evidence of a high loss among older bluegills during the summer, (Figure 8). During Period I, 17 percent of the catch (all 3, 4 and 5-year-old fish) was made up of 4 and 5-year old fish. By Period IX, these two oldest age groups had disappeared from the catch entirely.

The trap net set in previously unnetted Broken Arrow Slough during Period IX took no bluegills large enough to be considered 4 or 5-year-old fish (Figure 6). From this evidence it appears likely that the removal of bluegills during the summer's netting at the regular stations had little effect upon the length-frequency of the catch.

No migration of bluegills was noted during the summer, and it is probable that most of the losses of the older bluegills during this period was due to natural mortality.

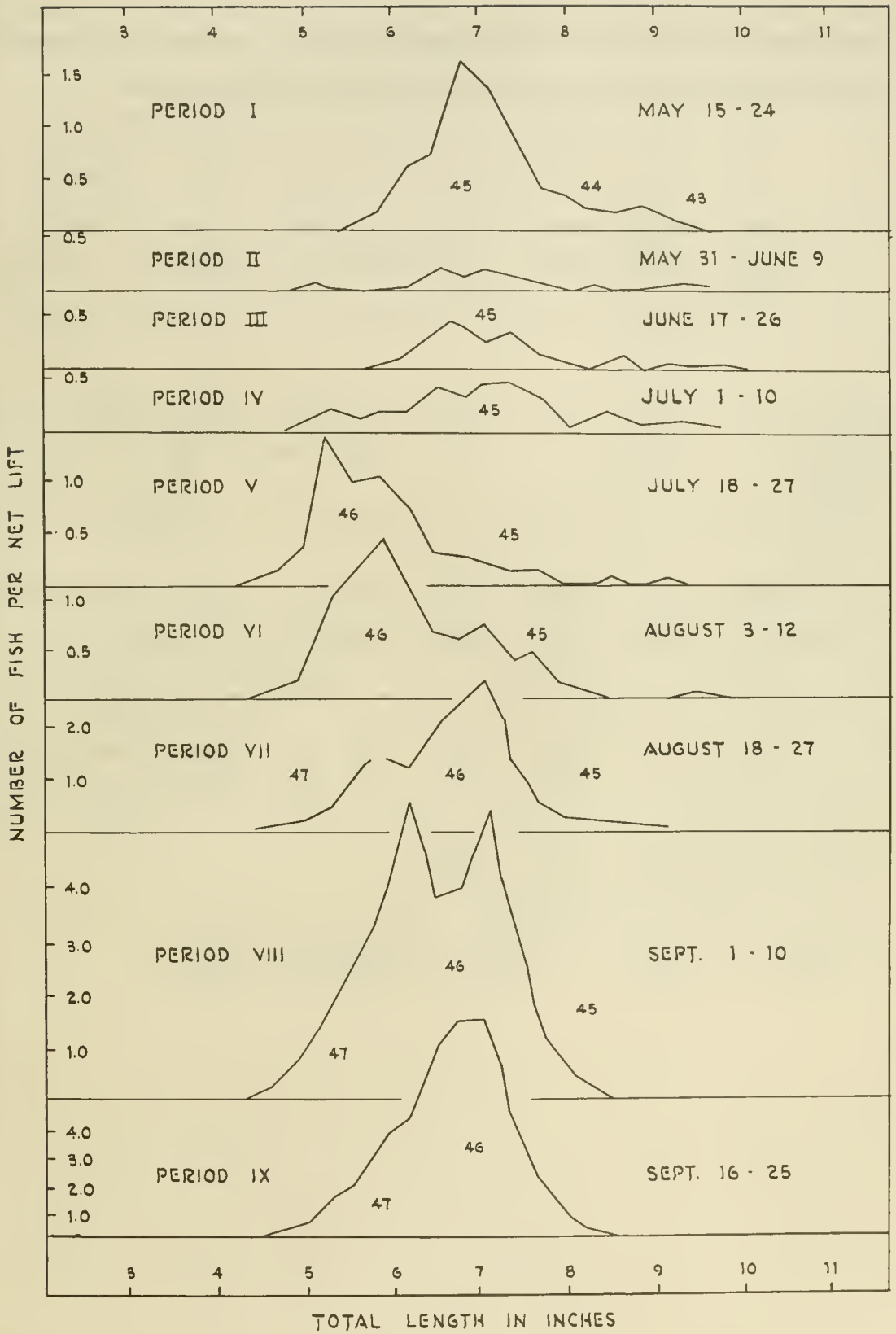

Fig. 8--Length-frequency distribution of bluegills for the nine netting periods. Approximate distribution of year classes was determined from scales.

Table 8. Mean catches of "recruited" and "residual" bluegills, expressed as numbers per net lift and percentage of the total catch for each netting period.

Period	I May 15–24	II May 31 June 9	III June 17–26	IV July 1–10	V July 18–27	VI Aug. 3–12	VII Aug. 18–27	VIII Sept. 1–10	IX Sept. 16–25
Recruited									
Number per lift	-	0.1	-	0.5	5.0	6.9	15.3	32.6	47.0
Percent of total	-	8	-	16	81	87	88	92	92
Residual									
Number per lift	6.8	1.2	2.6	2.7	1.2	1.0	2.1	2.8	4.1
Percent of total	100	92	100	84	19	13	12	8	8
Total number per lift	6.8	1.3	2.6	3.2	6.2	7.9	17.9	25.4	51.1

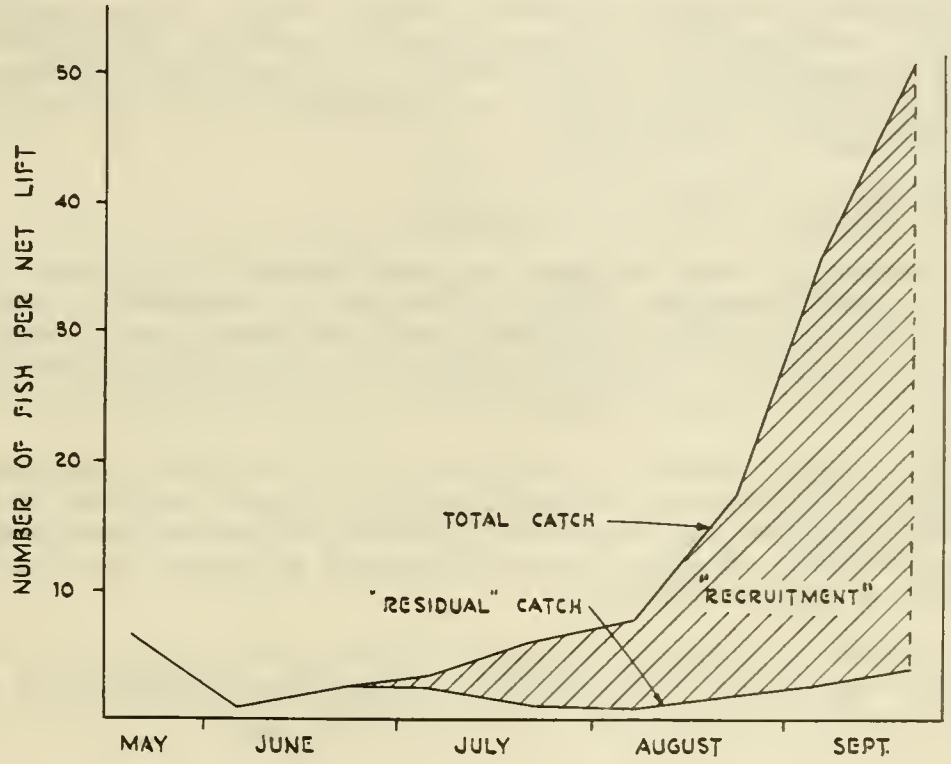

Fig. 9--Fluctuation in bluegill catch showing effect of "recruitment". Data from Table 8.

3. Activity of the Bluegill and the Catch.

Apparently all the significant fluctuations in the catch of bluegills, except the rise during July due to recruitment, were influenced by changes in the rate of activity of the fish. The drop in catch rate during June can, like similar drops in the white and black crappie catches, best be attributed to a decreased activity rate alone. Also the increase in bluegill catch during August and September can largely be attributed to an increase in the activity rate of bluegills. It should be noted however that most of the fish affected by this increase in activity rate were "recruited" bluegills that had not been available during the early netting periods.

Changes in activity rate were probably related to environmental changes. The drop in catch during the first part of June coincided with the stabilization of water levels after the spring high-water period. The drop in catch also was coincidental with water temperatures rising above 70 degrees F.

4. The Effects of Spawning Activities.

A summary of data gathered from examination of the gonads of bluegills caught in trap nets during the season is presented in Table 9. Gonads from the bluegills indicated that many were spawning when the netting began in May. Spawning activities apparently declined during July and by the first of August no fish with ripe gonads were taken.

There was no change in the catch of the "residual" bluegills which coincided with change in the spawning activities as measured by gonad analysis. However the 2-year-old bluegills, (like the 2-year-old black crappie and white crappie) entered the catch with the older fish as spawning activities declined.

Most of the 2-year-old bluegills examined had either ripe or spent gonads. They were sexually mature and apparently spawned apart from the older fish during the first part of the 1948 season.

SUMMARY OF BLUEGILL CATCH TRENDS

1. The means of bluegill trap net catches for the nine netting periods fluctuated between 1.3 and 51.1 fish and 0.5 and 13.5 pounds of fish per net lift. There was (1) a sharp drop during the first part of June and (2) a continual rise during July, August and September.

2. The sharp drop in catch during the first of June is thought to have been caused by a decrease in the activity of the bluegills. This decrease may have been caused by (1) stabilization of water levels after

Table 9. Gonad development of bluegills, showing percentage of gonad examined that were assigned to each developmental stage.

Period	I May 15-24	II May 31 June 9	III June 17-26	IV July 1-10	V July 18-27	VI Aug. 3-12	VII Aug. 18-27	VIII Sept. 1-10	IX Sept. 16-25
Number examined	216	54	68	105	189	298	629	477	330
Undeveloped	-	-	-	8.6	30.1	33.9	63.4	89.9	98.8
Developing	-	-	-	-	-	-	-	0.6	0.9
Ripe	33.4	14.8	16.2	22.8	1.1	-	-	-	-
Ripe †	66.6	81.2	79.4	54.3	19.5	-	0.2	-	-
Partly spent	-	3.7	4.4	3.8	1.6	0.3	-	-	-
Spent	-	-	-	10.5	47.6	65.8	36.4	9.4	0.3

the spring high water period, (2) water temperatures warming to above 70 Degrees F., or (3) both of these changes in environmental conditions.

3. The rise in catch during July was caused by recruitment of the 1946 year class as spawning activities declined.

4. The continued rise in catch after July resulted from effects of recruitment and increased activity of the bluegills. The increased activity of previously recruited bluegills had the most effect on the catch.

CATCH TRENDS FOR OTHER SPECIES

Seasonal fluctuation in the catch of eight other species is described below. These species were not taken in quantities large enough to justify detailed analysis of catch fluctuations but it is felt that trends in their catch during the season are worth noting. Mean catches of these species for individual netting periods do not represent large numbers of fish and differences between the catch of successive netting periods may represent sampling errors as often as they do actual differences in abundance or activity of these species. Trends for the entire season are probably more significant.

Table 10 lists the mean catch for each of these eight species, for each netting period. Each mean catch is expressed as the number and pounds of fish per net lift.

Northern Pike

Four hundred northern pike weighing 1,279 pounds were caught in trap nets during the season. The mean catch for the entire season was 1.2 fish and 4.1 pounds of fish per net lift. Mean catches for individual periods fluctuated from 0.8 to 2.4 fish per lift and from 2.0 to 9.2 pounds of fish per lift. Northern pike catches were highest at the beginning of netting in May; declined during June and remained rather low during the remainder of the season.

White Bass

One hundred and forty-five white bass weighing 121 pounds were caught in trap nets during the season. The mean catch for the entire season was 0.4 fish and 0.4 pounds of fish per net lift. Mean catches for individual netting periods fluctuated from 0.1 to 1.1 fish per net lift and from 0.1 to 0.9 pounds of fish per net lift. A drop in catch similar to that observed in the centrarchid catch during the first of June, was evident in the catch of the white bass. The catch then increased until September.

Table 10. Seasonal fluctuation in mean trap net catches of the northern pike, white bass, channel catfish, flathead catfish, carp, northern redhorse, carpsucker and sheepshead; expressed as numbers and pounds of fish per net lift. No attempt has been made to evaluate these means statistically. "P" signifies present in very small numbers.

Period	I	II	III	IV	V	VI	VII	VIII	IX	Entire season
	May 15-24	May 31 June 9	June 17-26	July 1-10	July 18-27	Aug. 3-12	Aug. 18-27	Sept. 1-10	Sept. 16-25	May 15 to September 25
Northern pike										
Numbers	2.4	1.6	1.0	1.2	1.0	0.9	0.8	0.9	1.3	1.2
Pounds	9.2	4.9	3.7	4.1	2.8	3.1	2.0	2.7	4.3	4.1
White bass										
Numbers	0.5	0.1	0.1	0.2	0.3	0.5	0.5	1.1	0.8	0.4
Pounds	0.9	0.2	0.1	0.2	0.3	0.2	0.3	0.7	0.5	0.4
Channel catfish										
Numbers	1.0	1.9	0.5	1.6	0.2	P	P	P	-	0.6
Pounds	2.5	4.6	1.5	3.7	0.3	P	0.1	P	-	1.4
Flathead catfish										
Numbers	1.0	0.7	0.6	0.6	0.1	P	P	0.1	0.1	0.3
Pounds	0.3	3.2	2.4	3.4	0.1	P	0.5	0.4	1.2	1.3
Carp										
Numbers	2.6	1.8	1.8	2.1	2.6	1.3	1.9	1.4	2.5	2.0
Pounds	11.3	8.5	7.2	9.7	7.7	4.2	5.4	3.4	8.3	7.3
Northern redhorse										
Numbers	0.1	0.1	0.4	0.4	1.4	0.6	0.3	1.1	1.5	0.6
Pounds	0.2	0.3	0.8	1.1	3.1	1.4	0.6	2.3	3.6	1.4
Carpsucker										
Numbers	0.2	0.5	1.6	0.5	0.2	0.5	0.2	0.3	0.2	0.5
Pounds	0.8	1.6	3.2	1.3	0.6	1.7	0.7	0.6	0.8	1.3
Sheepshead										
Numbers	0.3	0.7	1.3	0.9	0.9	0.4	0.3	0.5	0.5	0.6
Pounds	0.7	1.0	1.8	1.1	1.0	0.4	0.2	0.5	0.4	0.8

Channel Catfish

One hundred and ninety-one channel catfish weighing 455 pounds were caught. The mean catch for the entire season was 0.6 fish per net lift and 1.4 pounds of fish per net lift. Mean catches for individual netting periods fluctuated from no fish at all to 1.9 fish and 4.6 pounds of fish per net lift. Channel catfish were most effectively taken in trap nets during their spawning period in June and July. Very few were caught after the last of July. Catch fluctuations were similar in the large mesh buffalo nets set in the main channel. A drop in catch during the latter part of June coincided with a period of cool weather, almost daily rainfall, and a few degrees drop in water temperature. It is interesting that this sudden but temporary decline in channel catfish was predicted by the commercial fishermen who handled the nets with the author.

Flathead Catfish

Eighty-three flathead catfish weighing 390 pounds were caught. The mean catch for the entire netting season was 0.3 fish per net lift and 1.3 pounds of fish per net set. Mean catch for individual netting periods fluctuated from 0.02 to 0.7 fish and from 0.05 to 3.4 pounds of fish per net lift. Like the channel catfish, most of the flathead catfish were caught in trap nets during their June-July spawning season. A drop in catch rate, less than that of the channel catfish, occurred with the cool rainy weather during the latter part of June. Flathead catfish were taken fairly regularly during most of the season in large mesh buffalo nets set in the main channel.

Carp

Six hundred and forty-four carp weighing 2,317 pounds were caught in trap nets during the season. The mean catch for the entire netting season was 2.0 fish per net lift and 7.3 pounds of fish per net lift. Mean catches for individual netting periods fluctuated from 1.3 to 2.6 fish and from 3.4 to 11.3 pounds of fish per net lift. There was less fluctuation in the carp catch when expressed as numbers of fish than in the catch of any other species. There did not seem to be any particular trend in catch fluctuation although catch was lowest during August and the first part of September.

Northern Redhorse

Two hundred and seven northern redhorse weighing 472 pounds were caught in trap nets during the season. The mean catch for the entire season was 0.6 fish per net lift and 1.4 pounds of fish per net lift. Mean catches for individual netting periods fluctuated from 0.1 to 1.5 fish and from 0.2 to 3.6 pounds of fish per net set. The catch rate rose during June and July; declined during August; and rose again during September.

Carpsucker

One hundred and forty-six carpsucker weighing 394 pounds were caught in trap nets during the season. The mean catch for the entire season was 0.5 fish per net lift and 1.3 pounds of fish per net lift. Mean catches for individual netting periods fluctuated between 0.2 and 1.6 fish and between 0.6 and 3.2 pounds per net lift. Catch was highest during the June spawning period. Catch in the large mesh buffalo nets set in the main channel was also highest at this time.

Sheepshead

One hundred and ninety-eight sheepshead weighing 247 pounds were caught in trap nets during the season. The mean catch for the entire season was 0.6 fish per net lift and 0.8 pounds per net lift. Mean catches of individual netting periods fluctuated from 0.3 to 1.3 fish and from 0.2 to 1.8 pounds of fish per net lift. The catch rate increased during June; declined during July and August; and increased slightly during September.

SUMMARY AND DISCUSSION

1. In order to study seasonal trends in trap net catches, five permanent netting stations were selected in backwaters of the Upper Mississippi River a few miles below La Crosse, Wisconsin. One trap net was fished at each of these stations, for nine 10-day netting periods that were evenly spaced between May 15 and September 25, 1948.

2. Eleven species were caught in quantities large enough to note catch trends during the season. Fluctuations in mean catch during this four and a half month period were considerable. They were greatest for the black crappie and the bluegill, and least for the carp and the white crappie.

3. Three species, the black crappie, the white crappie, and the bluegill were caught in quantities large enough to allow study of causes of catch fluctuations. These causes may be divided into two groups, (1) those that resulted in changes in abundance of fish, and (2) those that resulted in changes in the rate of activity of the fish. Evidence was gathered that both abundance and activity rate of bluegills and black crappies changed considerably during the season.

4. About 40 percent of the black crappies, 60 percent of the white crappies, and 90 percent of the bluegills, caught during August and September were fish of the 1946 and 1947 year classes that had not been available during May and June. The 1947 year class was not available during the early part of the season because these fish were too small to be retained in the nets. The 1946 year class was not available because these fish were apparently not in the netting area during the spawning season.

5. Recruitment of the 1946 and 1947 year classes of black crappies, bluegills and white crappies influenced catch rates by (1) causing a rise during July when these year classes first appeared, and (2) magnifying the effects of increased activity rate among the bluegills and black crappies during August and September.

6. There was some evidence of high losses among older crappies and bluegills during the season. Fewer members of the 1944 and 1943 year classes were caught as the season progressed. Loss of older fish from the population is thought to have been largely the result of natural mortality.

7. The stabilization of water levels and the warming of waters to above 70 degrees F., in June may have been related to a decreased rate of activity noted among the centrarchids.

8. No relationship was noted between changes in water turbidity and catches of trap nets.

9. Spawning activities were apparently related to the high catches of channel and flathead catfish during June and the first part of July and to the high catch of carpsuckers during the last half of June.

10. Species composition of the total catch by weight changed markedly throughout the season (Figure 10). During Period III (June 12-26) 68 percent of the catch was of commercial species; 13 percent of panfish and 18 percent of game fish. A month later in Period V (July 18-27) 60 percent of the catch was of commercial species; 27 percent of pan fish and 15 percent of game fish. In Period VII a month later (August 18-27) 25 percent of the catch was of commercial species; 59 percent of panfish and 10 percent of game fish. Such changes in composition of the catch probably do not represent similar changes in the structure of the fish population of the area fished. They do demonstrate that several factors influence the catch of stationery nets and these must be taken into account if catches from such nets are to be used to estimate fish population, size and structure.

ACKNOWLEDGEMENTS

The writer wishes to acknowledge aid and encouragement received from conservation agencies of the states of Minnesota, Wisconsin and Iowa and the U.S. Fish and Wildlife Service. Special thanks are due Mr. Joe Martel for aid in the netting, Mrs. Wentzel Satek for assistance in the laboratory, Dr. John T. Greenbank who supervised the field work and gave generously of his time and advice and Dr. Raymond E. Johnson and Dr. John B. Moyle who helped prepare and revise the manuscript. Work in the field was carried out from the U.S. Fish Cultural Station at La Crosse, Wisconsin where space and facilities were made available by Mr. C. F. Culler, Mr. Harry Canfield and Mr. Harry Carson. The photograph of the trap net was supplied by Mr. John Dobie.

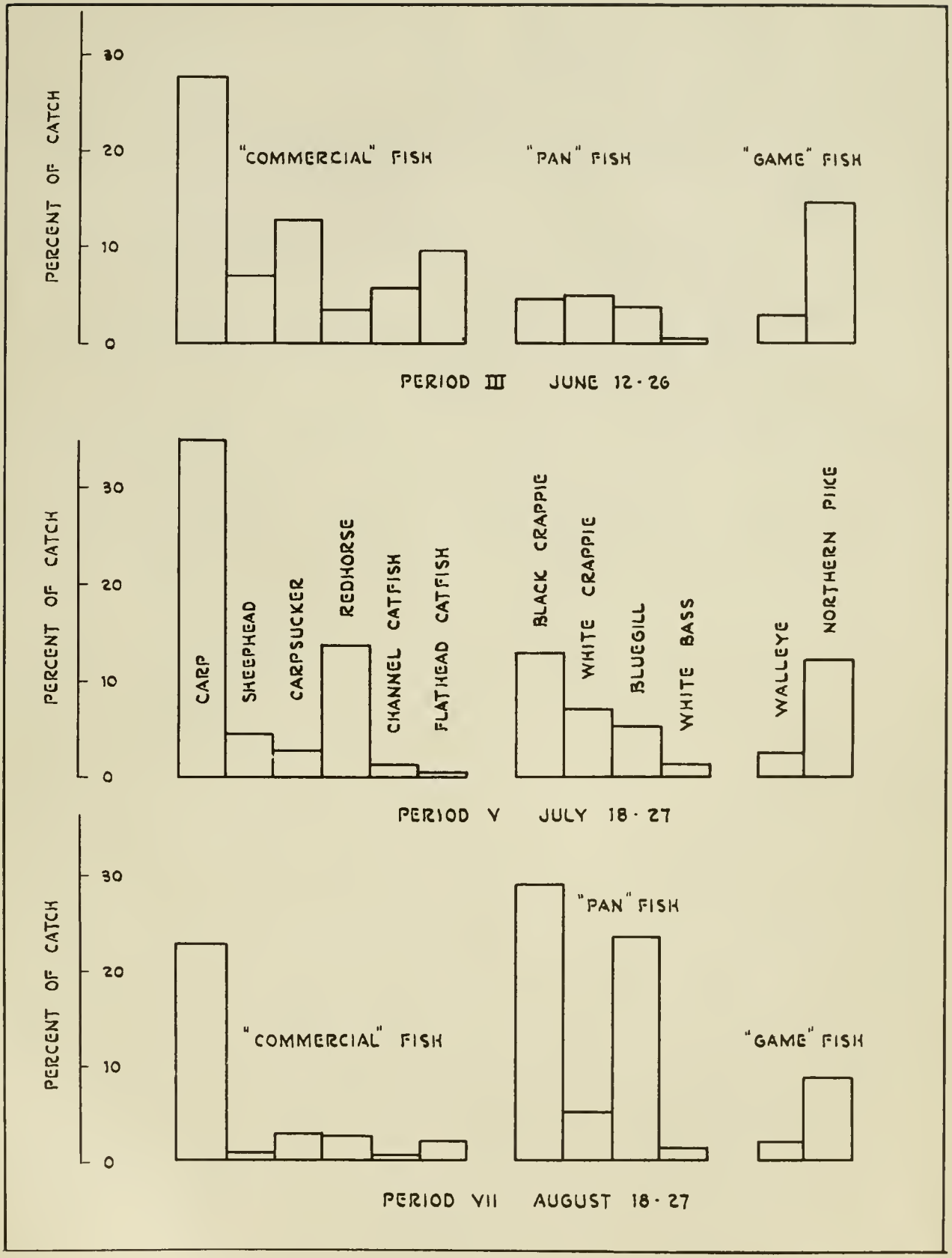

Fig. 10--Precentage composition of the total catch expressed as numbers of fish in netting periods III, V and VII, showing changes in structure of the catch as the season progressed. Catches of less common species are omitted.

REFERENCES CITED

Fry, F. W. J. and J. S. Hart
1948. Cruising speed of goldfish in relation to water temperature. J. Fish. Res. Bd. Can. Vol. 7 (4) 1948 pp. 169-175.

Hartley, P. H. T.
1947. The natural history of some British freshwater fishes. Proc. Zool. Soc., Vol. 117, Part I, pp. 129-206.

Hubbs, Carl L. and Alfred Perlmutter
1942. Biometric Comparison of Several Samples with Particular Reference to Racial Investigations. The American Naturalist, Vol. LXXVI, pp. 582-592. Nov.-Dec. ,1942.

Moyle, John B.
1950. Gill nets for sampling fish populations in Minnesota waters. Trans. Am. Fish. Soc., Vol. 79, 1949, pp. 195-204

Smith, Lloyd L., Jr. and Normal L. Moe
1944. Minnesota fish facts, Minn. Dept. of Cons. 28 pp.

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